Precision Livestock Farming.

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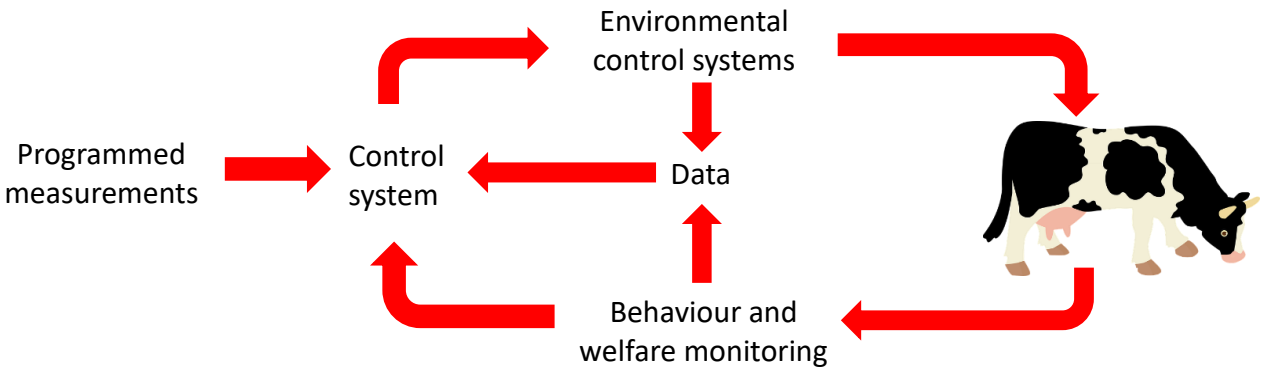
Take home messages:

- Precision livestock farming aims to increase animal productivity, improve animal welfare and health, whilst reducing environmental impact.
- The improvement of animal productivity is achieved using real time monitoring and management systems, alerting the farmer instantly when problems arise.
- Production related information generated from PLF systems can enhance farm management but cannot replace entirely the farmers own knowledge and experience.

Introduction

Precision livestock farming (PLF) enables the utilisation of technology within livestock systems to provide opportunities for better farm management and sustainable development. There have been several new technologies available to aid farm workers with daily tasks, such as livestock feeding and general health monitoring with the aim to increase animal productivity, improve animal health and welfare whilst reducing environmental impact. PLF integrates the use of 'smart' sensors into livestock farming, which links production processes into a complex network. These new technologies may be advantageous in terms of economic benefit and reducing manual workload. However, there may be a balance to be reached regarding the implementation of new technologies and the impact this may have on human-animal relationships.



Overview of PLF adapted from Wathes *et al.* (2008) https://doi.org/10.1016/j.compag.2008.05.005.

Available Technology

The implementation of new technologies can significantly reduce workload and free-up the farmers time by providing a real-time management and monitoring applications. Such technology enables farmers to monitor animals closely providing support during production, therefore any problems that arise can be identified swiftly and dealt with immediately. Although, currently much of the new technologies in place are principally targeted at dairy cows, pigs and poultry, the automatic control and monitoring offers possibilities to develop on farm management throughout the livestock industry. Some examples of PLF systems are as follows:

Precision Monitoring Systems

The PLF approach offers crucial monitoring of the animals themselves as each animal is an individual and will respond differently to its environment. The animals are thus labelled as CIT systems (Complex, Individual and time variant). Through PLF systems various measurements are able to be made and recorded, such as behaviour, food and water intake, weight, temperature, respiration rate and sounds produced by the animals to assess health status. Predicted measurements are made from an integrated algorithm in the monitoring system, which enables any deterioration of the animal from the 'normal' measurements to be flagged up and thereby addressed quickly. The use of these monitoring systems also has the added advantage that information can be recorded without causing the animals undue stress or disturbance. An example of a recent system under development monitored the gait and

weight of pigs. Vaughn et al., (2017), discuss the development of a smart sensor to determine gait analysis from guided-path tomography images or the use of machine learning by developing a floor system for harsh environments that can be added to farm systems without disturbing the animal's daily routine. Other systems include eYeScan, which used 3D video image recognition to monitor the growth of a group of animals and eYeNamic, which is used in both pigs and poultry systems to measure animal activity. Not only can movement and behavioural changes be monitored, but also for example, blood changes in the body can be detected by the utilisation of thermatographic cameras. For example, the CaDDi camera system used in Sweden is able detect inflammation e.g mastitis. Another important use of PLF monitoring systems is that by implementing such rigorous systems, animals are able to be treated at an earlier stage, therefore lowering costs required for treatment medication and reducing the reliance on antibiotics. For example, algorithms have been developed to determine sick coughs amongst pigs, which have demonstrated during field trials that sick coughs could be accurately classified in 86% of cases.

Precision Feeding Systems

Time saving is also important in terms of feed distribution. Precision feeding enables the correct composition of feed to be delivered at set intervals. For example, the implementation of automatic calf feeders can provide a cost-effective alternative to manual feeding regimes. As herd size increases the implementation of automated feeding systems (AFS) are becoming more common to reduce labour and improve calf health. By using these PLF systems data can be recorded relating to feeding behaviour which can be associated with certain disease states. AFS also allows calves to self-regulate feed intake throughout the day, which has been shown to be beneficial both in terms of animal welfare and production. However, sanitation within these systems has shown to be of utmost importance in maintaining animal health. Feeding units have been developed for a variety of animal systems, including cattle, sheep and pigs. These systems can be advantageous by providing an interface that monitors time and date of feeding, the electronic identification of each animal, the weight of the feed consumed and the duration of feeding. Ultimately the goal of these systems is to reduce feed waste, labour and cost whilst promoting healthier and more productive animals.

Impacts

Advantageous as some of these systems can be, there is still room for improvement. For example, in some instances the complicated nature of the system makes it less intuitive for

the farmer to put into practice and connectivity issues may also arise in some areas. Large amounts of data are potentially recorded by using PLF systems, which need to be adapted for day to day running to avoid unnecessary warnings, only alerting the farmer instantly when true problems arise. The impact of these new technologies can in some instances increase pressures placed on farmers, for example, managing alarm systems and prioritising cases for intervention. The implementation of new technologies may also have a negative impact on human-animal relationships by reducing the amount of hands on time the farmer spends with the animals. However, animals have been shown to adapt quickly to new technology even enabling them more freedom. The use of precision technologies is modernising the farming profession and a balance needs to be reached between economic benefits and quality of life improvement.

Summary

As the intensity of livestock farming increases to keep up with worldwide demands, monitoring animal welfare alongside conducting day to day on farm tasks such as feeding and milking will be able to be considerably enhanced by the incorporation of PLF. The development of such systems is a complex process as monitoring animals requires continuous measurements, which produces large amounts of data. Thus, the implementation of PLF systems needs to simplify the data collection and analysis process to prevent the presentation of more problems to the farmer. Overall, PLF offers new possibilities to collect and analyse data in an automated and continuous manner and opportunities to improve food quality and safety, improve sustainability and production, enhance animal welfare and reduce environmental impact. However, the application of PLF on farm can only be used as a management tool to aid the farmer in decision making, ultimately PLF cannot replace the farmers knowledge and experience.

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